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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention]This invention relates to the high-speed operation organic EL device which forms the light source constituted from organic materials on a polymer optical waveguide board.

[0002]

[Description of the Prior Art]While IT (Information Technology) revolution progresses quickly in recent years, the optical-information-processing circuit which can process information is needed at high speed. In it, it excels in flexibility, and has a small light weight, and, moreover, a highly efficient optical-information-processing circuit is one of the parts needed. Improvement in productivity is [that the further miniaturization of the product using this and a thin weight saving are possible, and it is easy to deal with it because an information processing circuit has flexibility from points, such as processability and shock resistance,] also expectable. There are the following problems in such part development conventionally, and development is difficult.

[0003]The conventional optical-information-processing circuit is formed with the material of a quartz system formed on the silicon substrate, and there is no flexibility. Active devices included in an optical waveguide circuit, such as a light emitting device and a photo detector, are formed with the inorganic semiconductor, and these need the substrate which bears an elevated temperature, in order to produce, where a substrate is heated.

[0004]These days, the polymer waveguide film is proposed as an optical waveguide circuit which has flexibility (Hikita: "organic optical waveguide device", the Institute of Electronics, Information and Communication Engineers, Vol.81, No.1, pp.37-40 (1998)). However, the active device formed with the inorganic semiconductor as mentioned above is difficult to produce directly on the polymer waveguide which has flexibility in order to heat and form a substrate in an elevated temperature.

[0005]

[Problem(s) to be Solved by the Invention]In order to solve this problem, on the polymer waveguide which has flexibility, With the organic thin film in which low-temperature formation is possible. A light emitting device. The optical integrated circuit used as a light source. The trial to produce is made (Y.). [Ohmori and] H. Ueta and Y.Kurosaka, M. Hikita and KYoshino, "OrganicEL diode with waveguide devices", Nonlinear Optics, vol.22, pp.461-464 (1999). However, since the light emitting device constituted with the conventional organic materials is a light emitting device developed as a use of a display etc., there is a problem that speed of response is slow.

[0006]Although the luminescent material with high luminous efficiency is also developed, since those luminescent materials contain Ir atom and include a triplet emission process, it is the response time for about several ms, and only the speed of response of about several 100 kHz is obtained. Since about 200-300-nm thickness is required in order to obtain big luminescence intensity, and a small material of carrier mobility is included, a high speed response is difficult and it is difficult for applying as a light source of the optical-information-processing circuit which needs a high speed response.

[0007]On the other hand, with the inorganic semiconductor, compared with the light emitting device which used organic materials, since it is produced with material with big mobility, a high speed response is possible and what has the speed of response of 1 GHz or more using compound semiconductors, such as GaAs, is developed, but. It is difficult to produce directly on a polymer waveguide substrate, as shown previously.

[0008]Low-temperature formation is possible for the purpose of this invention on the polymer optical waveguide which has flexibility, and it is providing the high-speed operation organic EL device which can realize high-speed speed of response.

[0009]

[Means for Solving the Problem]A high-speed operation organic EL device this invention is characterized by that comprises the following.

A hole-injection transparent electrode for pouring in an electron hole.

An electron hole transporting bed which consists of an organic conductor film which is formed on said hole-injection transparent electrode, and has electron hole transportability electrical conductivity.

An organic luminous layer which carries out firefly luminescence because it is formed on said electron hole transporting bed and an electron hole and an electron recombine.

An electron transport layer which consists of an organic conductor film which is formed on said organic luminous layer and has electron-transport-property electrical conductivity, inside of a hole barrier layer which controls that an electron hole moves between an electron barrier layer which controls that an electron moves between an electron injection electrode for being formed

on said electron transport layer and pouring in an electron, and said electron hole transporting bed and an organic luminous layer or said electron transport layer, and an organic luminous layer -- at least -- on the other hand.

[0010]As for this invention, said organic luminous layer consists of a thin film of thickness (0.1 nm - 100 nm).

[0011]Even if low-temperature formation is possible and it makes a luminous layer thin by the above composition on a polymer optical waveguide board which has flexibility, while a luminous layer is formed so that light may be made to emit efficiently and accelerating speed of response, high-intensity luminescence can be obtained.

[0012]That is, an organic EL device formed on it is constituted by charge of an organic high polymer material using an optical waveguide in which, as for a high-speed operation organic EL device by this invention, a substrate has the flexibility constituted with a polymeric material. Therefore, since a high-speed operation organic EL device does not need a specific substrate like an inorganic semiconductor that it can form at low temperature, it can be directly produced on a polymer optical waveguide board.

[0013]If there is little this invention among said organic luminous layer, and said electron barrier layer or a hole barrier layer, by composition of the more than forming two or more combination layers which consist of one side, it can make a luminous region able to increase and can raise luminous efficiency.

[0014]A dye molecule distributes said organic luminous layer by a ratio of 0.01% - 30% of a volume fraction, and this invention is formed.

[0015]By the above composition, the high-speed operation organic EL device can acquire sufficient luminous efficiency.

[0016]This invention is an optical interconnection device provided with the above-mentioned high-speed operation organic EL device.

[0017]By the above composition, CPU, a various processing board, an optical fiber, etc. can be connected at high speed, and data communications and data processing can be performed at high speed.

[0018]

[Embodiment of the Invention]Drawing 1 is a figure showing the lamination of the organic electroluminescence (Electroluminescence) element 101 which is one gestalt of operation of this invention. A figure is a sectional view seen from the direction parallel to the polymer optical waveguide board 102 used as a substrate. The high-speed operation organic EL device 101 is formed on the polymer optical waveguide board 102 in order of the lower transparent electrode 1, the electron hole transporting bed 2, the electron barrier layer 3, the luminous layer 4, the hole barrier layer 5, the electron transport layer 6, and the counterelectrode 7. The polymer

optical waveguide board 102 comprises the lower clad layer 8, the waveguide core 9, the upper clad layer 10, the 2nd cladding layer 11, and the mirror structure 12.

[0019]The lower transparent electrode 1 is a hole-injection transparent electrode for pouring in an electron hole to the luminous layer 4. The transparent electrode is used in order to let the light which emitted light by the luminous layer 4 pass. The conductivity of an electron hole consists of a high organic conductor film, and the electron hole transporting bed 2 conveys an electron hole to the luminous layer 4. The electron barrier layer 3 controls it being formed between the electron hole transporting bed 2 and the luminous layer 4, and the electron poured in from the counterelectrode 7 moving, and passing through the luminous layer 4. The luminous layer 4 is an organic luminous layer which carries out firefly luminescence because the electron hole which was formed by the organic conductor film and poured in from each electrode, and an electron recombine. The hole barrier layer 5 controls it being formed between the electron transport layer 6 and the luminous layer 4, and the electron hole poured in from the lower transparent electrode 1 moving, and passing through the luminous layer 4. Electronic conductivity consists of a high organic conductor film, and the electron transport layer 6 conveys an electron to the luminous layer 4. The counterelectrode 7 is an electron injection electrode for pouring in an electron to the luminous layer 4.

[0020]The lower transparent electrode 1 and the counterelectrode 7 are formed, for example by a sputtering technique, and each class which consists of an organic conductor film is formed by an organic molecular-beam-deposition method.

[0021]Each transporting bed and a barrier layer are determined by the size of an energy gap for an electron or an electron hole to move in the inside of an organic conductor film, An electron and the energy gap over movement of an electron hole make a barrier layer the layer by which a transporting bed, an electron, and the energy gap over movement of an electron hole are large, and movement in an organic conductor film is controlled in a small layer with high electron conductivity and hole conduction nature.

[0022]In this invention, speed of response is accelerable by making thickness of the luminous layer 4 thin with 0.1 nm - 100 nm. Although making thin thickness, such as the electron hole transporting bed 2 and the electron transport layer 6, can also speed up speed of response, these layers have large carrier mobility from the first, and since thickness is thin also in the conventional structure, influence on speed of response is small. The dye molecule with small mobility is distributed, and since the thickness in the conventional structure is thick, speed of response can be most efficiently accelerated in the luminous layer 4 by slimming down the thickness of the luminous layer 4. This enables it to use a high-speed operation organic EL device as an optical-information-processing circuit. Since an electron and an electron hole are shut up by the electron barrier layer 3 and the hole barrier layer 5 in the luminous layer 4 and recombination is efficiently performed, even if it makes thickness of the luminous layer 4 thin,

high luminous efficiency can be held, and a high-intensity high-speed operation organic EL device can be realized. If there is either [at least] the electron barrier layer 3 or the hole barrier layer 5, sufficient luminous efficiency can be held.

[0023]The light which it was reflected by the mirror structure 12 of the polymer optical waveguide board 102, and the light which emitted light from the luminous layer 4 was led to the waveguide core 9, and spread the optical waveguide is emitted from the end face of a waveguide. In the lower clad layer 8 and the upper clad layer 10, the 2nd cladding layer 11 may be an ultraviolet curing epoxy resin which has a different refractive index, and may be gases, such as not only a solid but air. So that the boundary of the waveguide core 9 and the 2nd cladding layer 11 has accomplished the inclination which is 45 degrees in the mirror structure 12, and the light which emitted light with the high-speed operation organic EL device 101 may carry out total internal reflection and may be led to the waveguide core 9. The refractive index of the lower clad layer 8, the upper clad layer 10, and the 2nd cladding layer 12 is chosen.

[0024]Drawing 2 is a figure showing the lamination of the high-speed operation organic EL device 201 which are other embodiments of this invention. A figure is a sectional view seen from the direction parallel to the polymer optical waveguide board 202 used as a substrate. The high-speed operation organic EL device 201 on the polymer optical waveguide board 202, It is formed in order of the lower transparent electrode 1, the electron hole transporting bed 2, the 1st electron barrier layer 3a, the 1st luminous layer 4a, the 1st hole barrier layer 5a, the 2nd electron barrier layer 3b, the 2nd luminous layer 4b, the 2nd hole barrier layer 5b, the electron transport layer 6, and the counterelectrode 7. The polymer optical waveguide board 202 comprises the lower clad layer 8, the waveguide core 9, the upper clad layer 10, the 2nd cladding layer 11, and the mirror structure 12. About what has the same function as the example shown in drawing 1 by each part of this embodiment, the same reference mark is attached and detailed explanation is omitted. The combination layer which consists of the 1st electron barrier layer 3a, the 1st luminous layer 4a, and the 1st hole barrier layer 5a, and the combination layer which consists of the 2nd electron barrier layer 3b, the 2nd luminous layer 4b, and the 2nd hole barrier layer 5b have the same function as the electron barrier layer 3, the luminous layer 4, and the hole barrier layer 5 which were shown in drawing 1, respectively.

[0025]The lower transparent electrode 1 and the counterelectrode 7 are formed, for example by a sputtering technique, and each class which consists of an organic conductor film is formed by an organic molecular-beam-deposition method.

[0026]By repeating and forming an electron barrier layer, a luminous layer, and a hole barrier layer like this embodiment, a luminous region can be made to be able to increase and luminous efficiency can be raised. Even if it repeats and forms the above-mentioned combination layer by making thin enough thickness of the luminous layers 4a and 4b, it is

possible to accelerate speed of response as compared with the former.

[0027] Hereafter, an example describes concretely.

(EXAMPLE) The 1st example is described using drawing 1. Formation of the organic conductive layer in drawing 1 is formed by an organic molecular-beam-deposition method.

That is, an organic molecule is heated in the high vacuum about 10^{-5} Pa, and the laminated structure of the molecular layer of desired thickness is obtained by covering an organic molecular beam by a physical shutter.

[0028] In order that the lower transparent electrode 1 of the EL element formed on the polymer waveguide substrate 102 may let light pass, For example, it is constituted by the transparent electrode which comprises the mixture ITO (Indium-Tin-Oxide: yne jeu MUSUZU oxide) of the tin oxide and indium oxide, and is formed by the thickness of the range of 100 nm - 500 nm by a sputtering technique. In this example, the lower transparent electrode 1 was produced by ITO (Indium-Tin-Oxide: yne jeu MUSUZU oxide) of 300 nm of thickness.

[0029] The electron hole transporting bed 2 consists of a thin film of a diamine derivative with high electron hole transportability electrical conductivity, 4 and 4'-bis[N-(1-naphthyl)-N-phenyl-amino]-biphenyl (a-NPD), Or N, N'-diphenyl-N, N'-(3-methylphenyl)-1, and 1'-biphenyl-4, 4'-diamine (TPD) is used. Thickness is formed in 10 nm - 200 nm. In this example, the electron hole transporting bed 2 was produced by a-NPD of 30 nm of thickness.

[0030] The electron barrier layer 3 consists of a thin film of the metal-phthalocyanines complex which is a phthalocyanine complex, and a copper phthalocyanine, nickel phthalocyanine, zinc phthalocyanine, non-metal phthalocyanines, etc. are used. Thickness is formed in 1 nm - 50 nm. In this example, the electron barrier layer 3 was produced by 5 nm of thickness copper phthalocyanine.

[0031] The luminous layer 4 in the thin film of quinolinol aluminum 8-hydroxquinoline aluminum (Alq_3) which is a quinolinol complex, The rubrene (Ruburene) which is a dye molecule. Or by distributing the molecule of 4-(dicyano methylene)-2-methyl-6-(p-dimethyl aminostyryl)-4 H-pyran (DCM) in the range whose volume fractions are 0.01% - 30%. Yellow light is obtained in the range with an emission center wavelength of 550 nm - 610 nm. Although thickness is formed in 0.1 nm - 100 nm, thickness (10 nm - 20 nm) is preferred. If thinner than 0.1 nm, sufficient luminous efficiency will not be acquired, and if thicker than 100 nm, sufficient speed of response will not be obtained. If it is the range of 10 nm - 20 nm, luminous efficiency and speed of response can realize sufficient characteristic. 1% - 10% of the volume fraction of the dye molecule to distribute is desirable. If smaller than 0.01%, sufficient luminous efficiency will not be acquired, and if larger than 30%, sufficient luminous efficiency will not be acquired by the optical quenching by high concentration. Although the optimal volume fraction changes also with dye molecules, when it is the above-mentioned dye molecule, if it is 1% - 10% of range, sufficient luminous efficiency will be acquired. In this example, in the quinolinol

aluminum (Alq_3) of 10 nm of thickness, the rubrene (Ruburene) of 7% of the volume ratio was distributed, the luminous layer 4 was produced, and yellow light with a luminous wavelength of 560 nm was obtained.

[0032] The hole barrier layer 5 consists of a thin film of the derivative which has a phenanthroline skeleton, 4, 7-Diphenyl-1, 10-phenanthroline (Bathophenanthroline), 2, and 9-Dimethyl-4, 7-diphenyl-1, 10-phenanthroline (Bathocuproine) etc. are used. 4 and 4'-dicarbazolyl-1, 1'-biphenyl (CBP) is also the effective organic materials as a hole barrier layer, and thickness is formed in 1 nm - 50 nm. In this example, the hole barrier layer 5 was produced by Bathocuproine of 5 nm of thickness.

[0033] The metal complex in which the electron transport layer 6 has a quinolinol skeleton (it 8--hydroxquinolinealuminum(s) (Alq_3) and) The thin film of tris(4-methyl-8-quinolinolate) aluminum(III) (Almq_3) is used, and phenylene oligomer (p-sexiphenyl etc.) is also used as an electron transport layer with big electrical conductivity. Thickness is formed in 10 nm - 200 nm. In this example, the electron transport layer 6 was produced by Alq_3 of 10 nm of thickness.

[0034] The counterelectrode 7 forms the metal electrode which RICHUMU mixed at a rate of 0.1% - 2% with the atomic ratio to aluminum in the range of 50 nm - 300 nm of thickness, in order to make small a potential barrier with the electron transport layer 6. Aluminum may be further used for aluminum as epiboly and the negative pole in 200 nm - 500 nm from the metal which mixed the RICHUMU atom. In this example, the metal which mixed the RICHUMU atom 1% to aluminum of 200 nm of thickness was produced as the counterelectrode 7.

[0035] As the characteristic of the high-speed operation organic EL device 101 of the 1st example produced as mentioned above, luminosity $30,000 \text{ cd/m}^2$ was obtained with the impressed electromotive force of 12V, and external-quantum-efficiency 1 cd/A was obtained. Compared with the element of structure, the improvement of one about 3 times the luminescence intensity of this and luminous efficiency was made conventionally which consists of the electron hole transporting bed, luminous layer, and electron transport layer in which this does not have the electron barrier layer 3 and the hole barrier layer 5.

[0036] When 33 ns of cycles, 15 ns of pulse width, and the pulse voltage of 13V were impressed to the element of electrode area 2 of 0.1 mm, the light emitting waveform corresponding to impressed electromotive force was obtained. As for this response characteristic, compared with the conventional organic EL device, the improvement of the speed of response of 3 times or more was made. The element by this invention is speed of response also including the stray capacitance of the electrode by element composition, and the speed of response of not less than 100 MHz becomes realizable by forming an electrode area still smaller.

[0037]The 2nd example shown in drawing 2 is effective in increasing a luminous region by adopting the structure which repeated and laminated the electron barrier layer 3 in the 1st example of the above, the luminous layer 4, and the hole barrier layer 5. 2 times - three repetitions are suitable for this repetition. If a repetition layer has either [at least] the electron barrier layer 3 or the hole barrier layer 5, it can hold sufficient luminous efficiency.

[0038]As explained above, the high-speed operation organic EL device 101,201 by this invention becomes possible [forming an element directly on the polymer waveguide substrate 102,202] by using organic materials other than an inorganic semiconductor material. And the optical integrated circuit which has flexibility with the organic EL device which accelerated speed of response can be provided. Although the speed of response conventionally realized with the organic EL device of structure was about several MHz, in the high-speed operation organic EL device by this invention, the speed of response of about several 100 MHz is realizable. This invention provides an optical integrated circuit by simple production processes, and since it is a circuit with flexibility, it can provide cheaply the element which is rich in lightweight processability by using for a portable device.

[0039]The optical interconnection device which connects a board, an optical fiber, etc. which carry arithmetic processing circuit elements, such as CPU and an image processing chip, and an arithmetic processing circuit element the high-speed operation organic EL device shown by this invention by having as a light-emitting part. Data communications and data processing can be performed more at a high speed.

[0040]

[Effect of the Invention]As mentioned above, according to this invention, on the polymer optical waveguide which has flexibility, low-temperature formation is possible and high-speed speed of response can be realized.

[0041]According to this invention, even if it makes a luminous layer thin, while the luminous layer is formed so that light may be made to emit efficiently and accelerating speed of response, it is possible to obtain high-intensity luminescence.

[0042]According to this invention, a luminous region can be made to be able to increase and luminous efficiency can be raised.

[0043]According to this invention, between CPU-to-CPU and a various processing board, between optical fibers, etc. can be connected at high speed, and data communications and data processing can be performed at high speed.

[0044]

[Translation done.]

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CLAIMS

[Claim(s)]

[Claim 1]A high-speed operation organic EL device comprising:

A hole-injection transparent electrode for pouring in an electron hole.

An electron hole transporting bed which consists of an organic conductor film which is formed on said hole-injection transparent electrode, and has electron hole transportability electrical conductivity.

An organic luminous layer which carries out firefly luminescence because it is formed on said electron hole transporting bed and an electron hole and an electron recombine.

An electron transport layer which consists of an organic conductor film which is formed on said organic luminous layer and has electron-transport-property electrical conductivity, inside of a hole barrier layer which controls that an electron hole moves between an electron barrier layer which controls that an electron moves between an electron injection electrode for being formed on said electron transport layer and pouring in an electron, and said electron hole transporting bed and an organic luminous layer or said electron transport layer, and an organic luminous layer -- at least -- on the other hand.

[Claim 2]The high-speed operation organic EL device according to claim 1, wherein said organic luminous layer consists of a thin film of thickness (0.1 nm - 100 nm).

[Claim 3]The high-speed operation organic EL device according to claim 1 or 2 forming two or more combination layers characterized by comprising the following.

Said organic luminous layer.

It is one side when small among said electron barrier layer or a hole barrier layer.

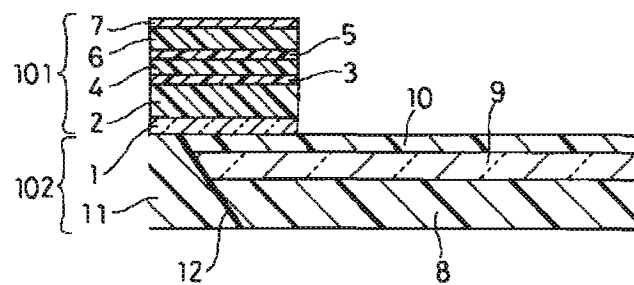
[Claim 4]A high-speed operation organic EL device of any one statement of claim 1-3 which a dye molecule's distributing said organic luminous layer by a ratio of 0.01% - 30% of a volume

fraction, and forming.

[Claim 5]An optical interconnection device provided with the high-speed operation organic EL device according to claim 1 to 4.

[Translation done.]

Drawing selection Representative drawing



[Translation done.]

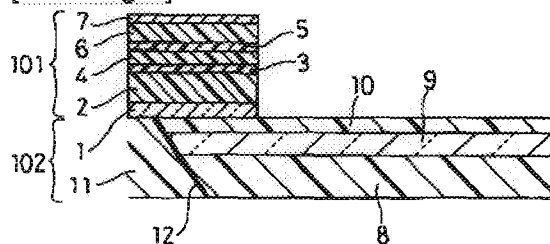
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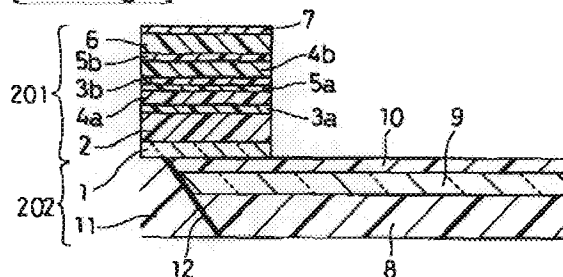
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DRAWINGS

[Drawing 1]



[Drawing 2]



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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1]It is a figure showing the lamination of the high-speed operation organic EL device 101 which is one gestalt of operation of this invention.

[Drawing 2]It is a figure showing the lamination of the high-speed operation organic EL device 201 which are other embodiments of this invention.

[Description of Notations]

- 1 Lower transparent electrode
- 2 Electron hole transporting bed
- 3 Electron barrier layer
- 4 Luminous layer
- 5 Hole barrier layer
- 6 Electron transport layer
- 7 Counterelectrode
- 8 Lower clad layer
- 9 Waveguide core
- 10 Upper clad layer
- 11 The 2nd cladding layer
- 12 Mirror structure
- 101 High-speed operation organic EL device
- 102 Polymer optical waveguide board

[Translation done.]